attracted to a permanent magnet as a powder as well as when dispersed in a solvent. This was a quick verification that zero valent nickel was generated.

Nano- and/or micro-scale zero valent metal particles were formed. Some of the particles prepared were large hollow spheres, while others were in aggregates of nano and micro particles. In one experiment, a total of about 415 particles were measured and their sizes ranged from about 0.4 μm to about 9.7 μm. The average particle size was about 1.9 μm with a standard deviation of 1.5 μm.

When solid powder of nickel produced from $Ni(OH)_2$ and NiO were dispersed in methanol under an ultrasonic treatment, TEM study showed a bimodal particle size distribution including micron sized primary particles (e.g., agglomerated particles) and nanoparticles. A particle size distribution of about 576 particles distributed log normal with an average maximum dimension of about 15.8 nm with a standard deviation of 12.1 nm. These results indicated the complexity of the particle formation process.

The A-RES Ni particles were created by "explosive" decomposition of urea. That is, 'trapped' urea explosively decomposed. The vast volume change upon decomposition (solid to gas) lead to significant volume expansion. In the case where the urea was "trapped", shattering of the encapsulating material to form nanoparticles occurred.

Control experiments were conducted by passing $Ni(OH)_2$ and NiO separately in the furnace at about 1000° C. without any urea. As a result, there was a slight change of color but neither powder was attracted by permanent magnet. That is, no zero valent metal was formed.

While the present teachings have been illustrated with respect to one or more implementations, alterations and/or modifications can be made to the illustrated examples without departing from the spirit and scope of the appended claims. In addition, while a particular feature of the present teachings may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular function. Furthermore, to the extent that the terms "including", "includes", "having", "has", "with", or variants thereof are used in either the detailed description and the claims, such terms are intended to be inclusive in a manner similar to the term "comprising." As used herein, the term "one or more of" with respect to a listing of items such as, for example, A and B, means A alone, B alone, or A and B. The term "at least one of" is used to mean one or more of the listed items can be selected.

Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the present teachings are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements. Moreover, all ranges disclosed herein are to be understood to encompass any and all sub-ranges subsumed therein. For example, a range of "less than 10" can include any and all sub-ranges between (and including) the minimum value of zero and the maximum value of 10, that is, any and all sub-ranges having a minimum value of equal to or greater than zero and a maximum value of equal to or less than 10, e.g., 1 to 5. In certain cases, the numerical values as stated for the parameter can take on negative values, in this case, the example value of range stated as "less than 10" can assume values as defined earlier plus negative values, e.g. −1, −1.2, −1.89, −2, −2.5, −3, −10, −20, −30, etc.

Other embodiments of the present teachings will be apparent to those skilled in the art from consideration of the specification and practice of the present teachings disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the present teachings being indicated by the following claims.

What is claimed is:

1. A method of forming metal particles comprising:

forming an aerosol stream comprising an inert carrier gas, one or more precursor compounds and a chemical agent that produces reducing gases upon thermal decomposition, wherein each of the one or more precursor compounds comprises one or more metals, wherein the aerosol stream comprises a solid concentration ranging from about 0.01% to about 50% by volume; and

flowing the aerosol stream through a heated inert atmosphere in a reduction expansion synthesis (RES) reactor to form a plurality of zero valent metal particles corresponding to the one or more metals of the one or more precursor compounds,

wherein a temperature of the heated inert atmosphere in the RES reactor is sufficient to thermally decompose the chemical agent to produce the reducing gas, and

wherein the plurality of zero valent metal particles include hollow sphere particles having a diameter ranging from about 10 nm to about 10,000 nm and pores in the order of about 1% to about 80% of the size of the hollow sphere particles.

2. The method of claim **1**, wherein each particle of the plurality of zero valent metal particles is a metal alloy particle comprising two or more distinct metals.

3. The method of claim **2**, further comprising controlling a metal ratio between the two or more distinct metals by controlling a metal ratio between the precursor compounds in the aerosol stream, wherein the precursor compounds each comprise different metal atoms.

4. The method of claim **1**, wherein the temperature of the heated inert atmosphere in the RES reactor is between a decomposition temperature of the chemical agent and a melting temperature of each of the one or more metal particles.

5. The method of claim **1**, wherein the one or more precursor compounds comprise oxides, hydroxides, nitrates, hydrated nitrates, nitrides, oxide-nitrides, or halogens of one or more metals, and wherein each of the one or more metals comprises a metal in one or more columns of IB, IIB, VB, VIB, VIIB, IA, IIA, IIIA, or IVA in the periodic table.

6. The method of claim **1**, wherein the chemical agent that produces reducing gases upon thermal decomposition comprises one or more nitrogen-hydrogen-containing molecules comprising urea $[(NH_2)_2CO]$ or a compound containing —NH or $—NH_2$.

7. The method of claim **1**, wherein each of the plurality of zero valent metal particles comprises a porous nanoparticle having a pore size ranging from about 1 nm to about 100 nm.

8. A method of forming metal particles comprising:

forming an aerosol stream comprising a metal precursor compound with a nitrogen-hydrogen (N—H) containing molecule in a carrier gas, wherein the metal precursor compound comprises a positive valent metal, wherein the aerosol stream comprises a solid concentration ranging from about 0.01% to about 50% by volume;

flowing the aerosol stream through a heated inert atmosphere in a vertically oriented reduction expansion synthesis (RES) reactor to form a plurality of zero valent metal particles corresponding to the positive valence metal; and